

# Libo Wu

EMBEDDED SYSTEM DEVELOPMENT

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## Summary

- Research experience in occupancy sensing, device-free human localization, tracking with machine learning approaches.
- Proficient in embedded system design, hardware integration, infrared sensor technologies.
- Strong skills with machine learning, PCB design, wireless communication, circuit design, and signal processing.
- Hand-on experience in 3-D printing, CAD design, product design, and troubleshooting.

## Education

### Texas A&M University

PH.D. CANDIDATE IN MECHANICAL ENGINEERING (TRANSFER STUDENT)

College Station, TX, USA

Aug. 2018 - Dec. 2020

### Stony Brook University

PH.D. CANDIDATE IN ELECTRICAL AND COMPUTER ENGINEERING

Stony Brook, NY, USA

Aug. 2015 - Jul. 2018

### University of Science and Technology of China

B.S. IN APPLIED PHYSICS

Hefei, Anhui, China

Aug. 2011 - Jun. 2015

## Skills

**Programming** Embedded C, Python, C/C++, Matlab, Assembler,  $\text{\LaTeX}$

ARM Cortex-M microcontroller development, communication protocols (I2C, UART, and SPI), RTOS, SolidWorks,

**Technical Skills** Machine learning, ML frameworks (Tensorflow, Keras), Wireless Communication (BLE, Zigbee), Labview, PCB design, Circuit design

## Experience

### SLEEP-IR Sensor Network for Human Presence Detection in Residential Buildings

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Dec. 2019 - Present

- Built a Zigbee/BLE based wireless sensor network. Each end device contains multiple sensors, including SLEEP-IR presence sensor, temperature/humidity sensor and light sensor.
- Implemented a hub that receives report from end devices and controls smart thermostats via a cloud service.

### Liquid Crystal Optical Shutter on Passive Infrared Sensor for True Presence Detection

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Aug. 2018 - Present

- Solved the common issue that all commercial motions sensors (PIR sensors) could not detect stationary occupants.
- Created a liquid crystal (LC) infrared shutter that can modulate long-wave infrared radiation with low driving voltage and ultra low power consumption (4.8V driving voltage with  $<10\text{nA}$ ) **[patent pending]**.
- Manufactured Polymer Dispersed Liquid Crystal (PDLC) infrared shutter with 8% modulation degree.
- Developed a synchronized low-energy electronically-chopped PIR sensor for true presence detection by applying the created LC shutter to a PIR sensor and being packaged in an extremely low power embedded system ( $\sim 20\mu\text{W}$ ).
- Designed realistic protocols for experiments which cover most regular daily actions and activities.
- Implemented the machine learning algorithm on the microcontroller. Extracted statistical features and ran machine learning algorithms (NN, SVM, Random Forest, etc.) for presence detection in real time.
- Reached 99.9% accuracy for true presence detection and over 97.7% accuracy for realistic protocols in a long-term test.

### Compressive Sensing for Human Localization Using Single Thermopile Pixel Sensor

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Aug. 2018 - Mar. 2019

- Designed a random binary mask to compress the radiation within the field of view (FOV) **[patent pending]**.
- Integrated one thermopile sensor and rotating optical mask to acquire compressive infrared signals from human.
- Built a physical model that shows the linear relationship among the output signal of sensor, the rotating mask and radiation distributions. Found the relationship could be solved by compressive sensing theory.
- Reconstructed spatial radiation distributions using basis pursuit denoising algorithm to recover localization information.
- Reached over 90% accuracy for localization of indoor the human object with a very low cost (less than \$10).

## Co-Mentor of Senior Design Project: Occupant-centered Light and HVAC Control Using Machine Learning for Human Comfort and Energy Efficiency

College Station, TX, USA

RESEARCH ASSISTANT

Fall 2019

- Guided and managed the team to build a lighting and HVAC control system under \$100 budget.
- Generated a Gantt chart to track the progress of the project. Assigned different tasks based on the skills of the team members.
- Gave guidance of selecting proper hardware (MCU, sensors, wireless communication), design concepts (mechanical and electrical), user-centered product development, and software development (reinforcement learning).

## Passive Infrared Sensor for Indoor Localization and Tracking

Stony Brook, NY, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Sept. 2017 - Mar. 2018

- Used a single passive infrared (PIR) and an optical shutter embedded with micro-controller unit (MCU) in the device to analyze the occupancy status of the indoor environment, such as presence, localization, and facial direction.
- Utilized an innovative rotating optical shutter in front of the PIR sensor to modulate the infrared radiation in a nonlinear manner. Built a physical model that shows the relationship between the output signal and the mechanical shutter.
- Extracted two features from the output signals from PIR sensors (peak to peak value, and pulse width).
- Applied machine learning methods (SVM and Neural Network) to improve the performance in predicting and classifying occupancy situations that reached 98% accuracy in localization.
- Extended the functionality of PIR sensors in indoor occupancy detection with high performance, such as human tracking with 0.44 m RSME, localization with 98% accuracy and facial direction detection with 83% accuracy.

## Long-term True Presence Detection Platform

Stony Brook, NY, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Jan. 2018 - Jun. 2018

- Utilized the low-power Lavet stepper motor ( $< 10\text{mA}$ ) to drive a mechanical optical shutter on PIR sensors for true presence detection that could detect both stationary and moving occupants [patent pending].
- Built a long-term experiment platform consists of Raspberry Pi, Pi camera, Shutterd PIR sensors and MCU.
- Used computer vision algorithms (YoLo and R-CNN) on videos to extract presence information as groundtruth.
- Reached 97% accuracy for classifying occupied and unoccupied scenes from 31-hour experiment.

## VLSI Course Project: VLSI Design for 8-bit Adder

Stony Brook, NY, USA

INSTRUCTOR: DR. EMRE SALMAN

Fall 2016

- Developed an 8-bit CSA adder with 45nm CMOS technology using Cadence software. The final design showed low power of 1.184 mW, low area of  $1257\ \mu\text{m}^2$ , and high speed of 4.34 GHz.

## Stony Brook University, Department of ECE

Stony Brook, NY, USA

TEACHING ASSISTANT

Aug. 2015 - Dec. 2017

- Embedded Microprocessor Systems Design (Fall 2016), Digital Systems Design (Spring 2016), Digital Signal Processing: Theory (Fall 2015)

## Publications

### JOURNAL PUBLICATIONS

- **Libo Wu**, Fangwang Gou, Shin-Tson Wu and Ya Wang, "Liquid Crystal Infrared Shutter for True Human Presence Detection Using Pyroelectric Infrared Sensors", *submitted to IEEE Sensors Journal*, 2020.
- **Libo Wu**, Fangwang Gou, Shin-Tson Wu and Ya Wang, "SLEEPIR: Synchronized Low-Energy Electronically-Chopped PIR Sensor for True Presence Detection", *to appear on IEEE Sensors Letters*, 2020.
- **Libo Wu**, and Ya Wang, "Compressive Sensing Based Indoor Occupancy Positioning Using A Single Thermopile Point Detector with a Coded Binary Mask", *IEEE Sensors Letters*, 3(12), pp. 1-4, 2019.
- **Libo Wu**, Ya Wang and Haili Liu, "Detection and Localization of Individuals by Monitoring Nonlinear Energy Flow of a Shuttered Passive Infrared Sensor", *IEEE Sensors Journal*, 18(21), pp. 8656-8666, 2018.
- **Libo Wu** and Ya Wang, "A Low Power Electric-Mechanical Driving Approach for True Occupancy Detection Using a Shuttered Passive Infrared Sensor", *IEEE Sensors Journal*, 19(1), pp. 47-57, 2018.

### CONFERENCE PROCEEDINGS

- **Libo Wu** and Ya Wang, "Compressive Sensing Based Indoor Human Positioning Using A Single Thermopile Point Detector", *12th International Workshop on Structural Health Monitoring, September 10-12, 2019, Stanford, California, USA*.
- **Libo Wu** and Ya Wang, "Shuttered Passive Infrared Sensor for Occupancy Detection: Exploring A Low Power Electro-Mechanical Driving Approach", *ASME SMASIS conference*, 2018 (Oral presentation).

## Patents

- **Libo Wu** and Ya Wang, "Shuttered Passive Infrared Sensor Apparatus with A Low Power LWIR Liquid Crystal Optical Modulator for Stationary and Moving Occupancy Detection", *U.S. Patent Application No. 62/880,058*, July 29, 2019.

- **Libo Wu** and Ya Wang, “A Single Thermopile Point Sensor Apparatus with A Set of Coding Masks (Compressive Sensing Matrix) for Indoor Human Positioning”, *U.S. Patent Application No. 62/863,823*, June 19, 2019.
- **Libo Wu** and Ya Wang, “Shuttered Passive Infrared Sensor Apparatus with A Low Power Lavet Motor Driving Approach for Stationary and Moving Occupancy Detection”, *U.S. Patent Application No. 62/863,808*, June 19, 2019.

## Certification

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**Online Course Certificate**      Machine Learning (Cousera), Deep Learning Specialization (Cousera), Mastering RTOS: Hands on FreeRTOS (Udemy), Mastering Microcontroller with Driver Development (Udemy)

## Honors & Awards

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- 2019    **Graduate Student Travel Award**, J. Mike Walker '66 Department of Mechanical Engineering
- 2019    **Graduate Excellence Scholarship**, J. Mike Walker '66 Department of Mechanical Engineering
- 2013    **Bronze Medalist**, Outstanding Undergraduate Scholarship